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EXECUTIVE SUMMARY

REACTOR WASTE MANAGEMENT RESEARCH PROGRAM 1986-1990

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This report presents a 5 year reactor waste management research program for the period 1986-1990 inclusive. The report was jointly developed by Research Division and Nuclear Materials Management Department. The intent of the document is to collate the various research studies to provide a focussed strategy addressing Corporate needs in this area. The scope of the program is in line with the priorities and interests identified in Research Division's Program Champions - Nuclear Waste recommendations (Report X86-19-R) and NMMD's Reactor Waste Management Policy.

Seven major research topics are identified, each containing a number of individual projects covering the following activities:

1. Waste Characterization

This research will characterize incinerable, compactable and non-processable solid wastes, ion exchange resin, and miscellaneous liquid wastes in respect of physical and chemical composition, activity levels, and radionuclide inventory. These data will be used to define the hazard level of the different waste streams, their conditioning needs for extended storage and disposal and to provide a measurement of activity and radionuclides in storage.

2. Waste Conditioning

This concentrates on development of solidification matrices and processes for liquid and dispersable wastes to produce waste forms suitable for extended storage at the Reactor Waste Operating Site (RWOS). Included are full scale tests to validate laboratory studies and prove the suitability of recommended treatments for operational use.

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3. Advanced Waste Treatment

Extended storage of reactor wastes creates a need for effective use of the engineered storage at the RWOS to minimise construction of additional structures. Research into aggressive decontamination techniques to allow metals to be disposed of as scrap, plasma arc incineration of resins or metal melting, and activity stripping from ion exchange resins are included in this section.

4. Process Equipment Development

Work in this area is in support of NMMD design and specification activities with regard to waste solidification, incinerator off-gas treatment, and new incinerator studies.

5. Waste Form Performance Evaluation

These studies aim to define the chemical and physical stability and radionuclide retention properties of waste forms over long time frames and under various environmental conditions that may be encountered in extended storage and disposal. Full scale field tests are proposed to determine correlation with laboratory results.

6. Waste Form Quality Assurance

There is a need to be satisfied that production waste forms have the required quality to ensure their suitability for storage. Tests to non-destructively assess waste form homogeneity, physical integrity, package quality, etc. will be developed. Specifications and criteria to measure quality will be proposed for inclusion in the QA program.

7. Engineered Barriers

The development and evaluation of backfills and grouts as added barriers in disposal facilities to radionuclide migration, the evaluation of materials that might be used in high integrity containers, and extended storage effects on waste form and package integrity are covered in this section.

In addition to the foregoing direct research we shall keep abreast of other research and technical developments by continuing participation in IAEA coordinated research programs and technical consultant activities, maintaining membership in OECD/NEA and CEC research advisory committees, and possible cooperative projects or scientist exchange with other research institutions.

It is proposed that the program be reviewed annually to ensure the continued appropriateness of individual projects within the objectives of NMMD's overall Reactor Waste Management Program and to reassign priorities, resources and funding as necessary.

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To: Mr. H.N. Isaac
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REACTOR WASTE MANAGEMENT RESEARCH PROGRAM
1986-1990

This report outlines a comprehensive 5 year reactor waste management research program for the period 1986 to 1990 inclusive, to provide a focussed strategy which addresses corporate needs in this area. Seven main areas of research are identified, each one being sub-divided into individual projects. The schedule and cost estimates are provided to indicate the level of activity considered desirable and necessary to fully investigate all reactor waste management options and are not intended to represent firm allocations of funds or resources. Priorities will be assigned annually to satisfy the specific needs of NMMD's overall reactor waste management program. Contributions to the scope of the report have been made by personnel of the Chemical Research, Civil Research, Electrical Research, and Nuclear Materials Management Departments.

This report presents a plan, jointly prepared by Research Division and Nuclear Materials Management Department, for a 5 year reactor waste management research program covering the period 1986-1990 inclusive. Personnel of the Chemical Research, Civil Research, Electrical Research, and Nuclear Materials Management Departments have contributed to the scope of the document.

The intent of the report is to collate the various research projects into a focussed strategy which addresses corporate needs in reactor waste management over the relevant time period. The scope of the program is in line with the priorities and interests identified in Research Division's Program Champions - Nuclear Waste recommendations (Report X86-19-R) and NMMD's Reactor Waste Management Policy.

Previous reactor operating waste research covered the development and evaluation of matrices for the solidification of aqueous wastes, investigation of conditioning processes for tritiated wastes, measurement of waste form performance and understanding radionuclide release mechanisms. Recently undertaken applied studies have concentrated on the characterization of various wastes in respect of physical composition, activity levels, and radionuclide inventory. Process engineering activity dealt with development of a compact aqueous waste solidification plant, the prototype of which is expected to be fully commissioned in mid 1986. This research was in support of Nuclear Materials Management Department's Reactor Waste Management Program which had the policy of early disposal of low and intermediate level radioactive wastes. In November, 1985, the concept of extended storage of the wastes was introduced. This has little effect on our research program as the wastes should be conditioned to be suitable for disposal at the outset to avoid double handling of the wastes. Indeed, extended storage offers possible research opportunities in advanced volume reduction techniques to minimize additional storage space requirements.

The schedule and cost estimates shown in Appendix 1 are intended to indicate the level of activity considered desirable and necessary to fully assess all reactor waste management options and alternative schemes and should not be viewed as a firm allocation of funds and resources. Part of this program would include engineering development work by NMMD to complement the basic research studies. Individual project priorities will be assigned and reviewed annually to ensure that the specific needs of NMMD's overall reactor waste management program are satisfied. It is expected that any commitment to undertake a particular project together with agreement on scheduling and funding will be negotiated between the principals involved on an individual basis.

REACTOR WASTE MANAGEMENT RESEARCH PROGRAM

Details of individual projects proposed for the 1986-1990 research program are presented in this section. Summaries of cost estimates and project schedules are given in Appendix 1.

1. WASTE CHARACTERIZATION

The objectives of the waste characterization studies are to establish activity levels and radionuclide inventories for all Ontario Hydro radioactive wastes in extended storage and determine conditioning treatments for individual waste streams to ensure their safe extended storage and eventual disposal. This information is needed by NMMD to satisfy regulatory authorities that our waste management practices are correct and will meet any regulatory requirements that may be introduced. Most of the research in this area will be completed in 1986, however non-processable waste characterization will continue until late 1987. Periodic characterization of incinerator ash between 1987 and 1990 will be undertaken as necessary to improve the data base and for input into ash immobilisation research. Ion exchange resin characterization will probably continue through to 1990, with extensive studies in 1987 and 1988 then at a reduced level in the remaining two years.

1.1 Incinerable Waste ($75K, 1986)

This involves the examination of bags of incinerable waste for their content of plastic, rubber, cotton, paper and other wastes. Plastic is identified as polyethylene, PVC, or other plastic and rubber is classified as natural, neoprene, or other. The mass and activity level of each bag is measured, selected bags are gamma scanned and H-3 and C-14 contents determined. These data will enable assessment of heat value, prediction of off-gas composition and estimation of radionuclide inventory and activity levels of the incinerator ash to be made. This will allow the specification of performance requirements for any new incinerator.

1.2 Non-processable Waste ($110K, 1986-87)

This class of waste covers materials not suited to incineration or compaction either because of their nature or activity level. This study is aimed at determining the composition, activity level, and radionuclide content of this waste. Of particular interest is the obtaining of such data for station filters. The data base developed will be used as a basis to assess the potential benefits of advanced volume reduction technologies for treatment of this type of waste and to identify equipment requirements for the WVRF to achieve any volume reduction necessary.

1.3 Retubing Waste ($55K, 1986)

Incinerable, compactable, and non-processable waste from the PNGS retubing operation are being examined to determine any variations in activity levels and radionuclide inventory, particularly C-14, from similar classes of waste produced in normal operations. Assessment of the level of alpha contamination on metallic components is also being attempted. This data will determine whether more rigourous conditioning is required for this waste than for normal operating wastes.

1.4 Ion Exchange Resins ($440K, 1986-90)

This project involves obtaining several samples of spent resin (moderator and PHT) from PNGS and BNGS using the Research Division developed resin sampler. The samples will be analyzed for beta-gamma radionuclides and C-14 content. Gamma scans will be made during sampling to provide support data for the resin analysis and to determine the representativeness of the samples. This work will allow estimation of the radioactivity in stored resin, establish conditioning needs, and form a basis for selection of the preferred treatment option eg, immobilisation and storage versus activity stripping and resin destruction.

1.5 Incinerator Ash ($100K, 1987-89)

Characterization of incinerator ash will be repeated as necessary to increase the data base and as required to provide input into ash immobilisation studies described in section 2.4 in support of conditioning for extended storage, transportation, and disposal.

1.6 Miscellaneous Liquid Wastes ($70K, 1986-87)

Miscellaneous liquid waste arisings such as contaminated lubricating oils, hydraulic fluids, mixed organic/aqueous liquids, liquids from supercompaction and the like will be characterized to determine their individual need for conditioning and to determine for each particular waste whether destruction, decontamination, or immobilisation is the appropriate treatment option. This will enable the development of the effective management strategy for these wastes that is required to be presented to AECB in 1987.

2. WASTE CONDITIONING

Waste conditioning studies will identify optimum immobilisation matrices and processes for liquid wastes, ion exchange resins, and easily dispersable materials such as incinerator ash. The license for the BNPD Radioactive Waste Operations Site requires liquid wastes to be solidified before they can be stored there. Ion exchange resins and incinerator ash are likely to require solidification to avoid the possibility of dispersion during extended storage.

Two major research projects that are necessary are continued study and optimization of solidification matrices and processes for spent ion-exchange resins and development of conditioning treatments for miscellaneous liquid wastes at BNPDS (mixed organic/oil/aqueous wastes) and liquid from waste supercompaction (organic/aqueous).

2.1 Miscellaneous Liquid Waste Conditioning ($150K, 1987-89)

Development of conditioning treatments for miscellaneous liquid wastes (oils, dry cleaning sludge, scintillation fluid, and chemical cleaning solvents) is required to reduce volumes and/or produce solid waste forms acceptable to AECB for storage at BNPD. This research will involve evaluation of volume reduction options (incineration, purification, concentration, segregation etc.), identification of matrices and processes for waste solidification, and determination of waste form suitability for storage and disposal.

2.2 Immobilization Matrices for IX Resin ($145K, 1986-89)

Two matrices, water extendible polymer and cement/epoxy, have been investigated for IX resin immobilization. The earlier research assumed C-14 would be present on the resin. Other matrix materials such as cement/asphalt, sulphur cement, LIF and fly ash require evaluation to ensure that the best combination of processing ease and waste form performance is identified and demonstrated. The carbonation properties of these matrices for the fixation of C-14 will be determined. In this research the effect of partial or complete removal of C-14 on conditioning requirements and waste form performance will also be addressed.

2.3 Full Scale Immobilization ($100K, 1988-89)

This involves demonstrating the quality of full scale waste forms produced by immobilisation processes recommended for various liquid and ion exchange resin wastes from bench scale studies. Where necessary processing techniques, mixing and curing conditions will be modified to enable production of large scale waste forms having similar physical and chemical properties and homogeneity to laboratory size specimens. Full size samples will be cored and sectioned to determine waste distribution and overall

characteristics. This will verify the suitability of conditioning processes recommended for operational use.

2.4 Immobilisation Matrices for Incinerator Ash ($80K, 1987-88)

Matrices and processes for the immobilisation of incinerator ash will be evaluated along with processing techniques capable of handling the various sizes of ash encountered. Waste form homogeneity, physical characteristics, durability and leaching performance will be measured to determine the most suitable process. An immobilisation treatment for incinerator ash is needed to avoid possible dispersion problems in extended storage.

2.5 Verification of Tritiated Waste Conditioning Methods ($120K, 1987-89)

Tritiated waste conditioning processes and packaging requirements have been developed and recommended on the basis of laboratory scale research. Large scale studies will be undertaken on the overall conditioning and packaging system to verify the earlier results and to demonstrate treatment suitability. The results are needed to support NMMD engineering recommendations to Darlington NGS.

3. ADVANCED WASTE TREATMENT

The increased emphasis on extended storage of reactor waste and the replacement of major system components at older stations (semi-decommissioning) highlights the need for research into advanced waste treatment technologies stressing volume reduction to limit demand for additional engineered storage structures. In these studies the suitability, benefits and disadvantages of the different treatments will be determined. Those with most potential will be recommended to NMMD for engineering consideration.

3.1 Aggressive Decontamination ($220K, 1987-89)

This research will examine the use of concentrated chemical solvents to remove radioactivity completely from metal components to allow disposal of the metal as scrap. Electropolishing coupled with electrodeposition to fix the radioactivity will also be studied. The efficiency of the treatment for radioactivity removal and optimum operational parameters will be determined to decide whether or not the technique should be adopted.

3.2 Plasma Arc Pyrolysis/Melting ($309K, 1988-90)

The proposed research in this area is to evaluate plasma arc incineration of special incinerable wastes and the feasibility of this approach to volume reduce metallic waste of low surface area to volume ratio. The technique will also be studied as a volume reduction process for ion exchange resins either before or after activity stripping and will complement the research on IX resin volume reduction (3.3). Data developed in this study will be used to in engineering assessments of possible implementation of the technology at the WVRF.

3.3 Ion Exchange Resin Volume Reduction ($430K, 1987-90)

Previous investigations of techniques for volume reduction of IX resin will be reviewed and updated. The applicability of these processes and others including wet oxidation, incineration, etc to resins containing C-14 and to resins from which the C-14 has been removed will be assessed. Process flowsheets including mass and energy balances will be prepared identifying all waste streams. Appropriate waste immobilisation techniques will be developed. The experimental program will include pilot scale studies (see also 3.2). Recommendations will be made to NMMD for equipment and performance requirements for use in their design activities.

3.4 C-14 Removal, Fixation and Recovery ($440K, 1987-89)

The acid stripping process for C-14 removal from ion exchange resin will be optimised on a laboratory scale then developed to the pilot plant stage. Methods for direct immobilisation of the removed C-14 on solid sorbents will be investigated. Processes to

recover C-14 for commercial purposes will also be studied. These data will allow the suitability of the processes and the performance of the waste forms to be assessed for possible operational implementation.

4. PROCESS/EQUIPMENT DEVELOPMENT AND TESTING

Waste conditioning and volume reduction research will identify processes and materials for treatment of the wastes. In cases where novel procedures are recommended, pilot scale equipment development may be required to define needed plant, process parameters and other engineering features. These activities will establish basic equipment requirements and performance criteria that can be used by NMMD in the design, specification, and procurement of new waste processing machinery for the RWOS or for improvement of existing apparatus.

4.1 Liquid Waste Solidification System ($260K, 1986-88)

A full scale prototype plant for the solidification of aqueous radioactive waste with water extendible polymer has been developed by Chemical Research. The prototype will be maintained and modified as necessary for experimental solidification of other waste streams such as resins, ash, and organic liquids. It will also be used to provide design verification to NMMD for operational units.

4.2 Waste Treatment Equipment ($341K, 1988-90)

Participate in the development or modification of equipment for the treatment of various wastes as required by prior research on aggressive decontamination, electrodeposition, C-14 stripping, plasma arc pyrolysis, and other advanced volume reduction techniques. Pilot plant information will be incorporated into full scale equipment design by NMMD.

4.3 Incinerator Off-gas Filter Efficiency ($65K, 1986-87)

An assessment of the performance of the baghouse at the BNPDS incinerator during maximum dust loading will be carried out and the combustion performance during the burn cycle will be evaluated. The information will be used in the design of a new incinerator system to replace the existing equipment.

4.4 Future Incinerator Off-gas Treatment Studies ($150K, 1987-89)

The operational requirements for the off-gas cleanup system will be defined by Design and Development Division. On the basis of these requirements the various technologies available for off-gas cleanup will be reviewed and assessed. Each system will be evaluated with respect to technical performance, effluent type and quantity, maintainability, and cost. Process flow diagrams will be prepared for the selected system(s).

5. WASTE FORM PERFORMANCE EVALUATION

There is a need to develop information on waste form durability and radionuclide release characteristics under disposal conditions. This involves large scale studies to determine effects of scale up from laboratory size on homogeneity, porosity, and physical properties. Field lysimeter tests are also necessary to determine radionuclide releases and retardation effects. This type of information will be required for disposal safety and licencing studies.

A better understanding of waste form behaviour will be developed to define factors and mechanisms influencing deterioration so that performance under actual conditions can be confidently predicted from laboratory and field tests. Test methods will be developed which closely simulate extended storage and disposal environments to increase the validity of laboratory tests.

5.1 Porosity and Surface Area Measurement ($250K, 1986-89)

Research into the pore characteristics, permeability, and specific surface area of porous cementitous and other waste forms and barrier materials will be undertaken. These characteristics will assist in the interpretation of the leaching behaviour of waste forms as well as water ingress and radionuclide retention of engineered barriers. The effects of aging and degradation due to both environmental and waste interactions on overall performance will also be defined.

5.2 Waste Form Durability ($152K, 1988-90)

This study will concentrate on examination of aging processes and deterioration mechanisms due to both the external environment and internal waste/matrix interactions to identify factors affecting immobilised waste forms physical and chemical stability, the rates of change, and the probable final condition of the waste form after long periods up to 300 years. The effect of the variations will be factored into packaging and/or engineered barrier requirements for both extended storage and eventual waste disposal.

5.3 Integrated Leaching Test ($212K, 1986-89)

Development of a bench scale integrated leaching test simulating ground water flow rates and in which the retardation effects of grouts and site soils on radionuclide releases from waste forms can be measured is underway. Test results will be correlated against results obtained from the proposed lysimeter test (5.4) to assess the viability of the laboratory test for waste form leaching performance determination. When complete the test will allow more accurate definition of specific source terms for various radioactive wastes.

5.4 Lysimeter Testing ($370K, 1987-90)

There is a need to develop knowledge of full size waste form leaching behaviour under actual field conditions. It is proposed to construct lysimeters at BNPD capable of accommodating appropriately conditioned full scale waste form and grout combinations and regularly analyze the percolate water to both derive realistic source terms and develop scale factors that can be applied to the laboratory integrated leaching test.

6. WASTE FORM QUALITY ASSURANCE

Quality assurance tests, methods, performance criteria, and specifications need to be developed and established to satisfy regulatory agencies that the various conditioned waste forms and packages are suitable for extended storage and disposal. Inspection methods, specifications, and criteria to determine that waste forms and packages are of the required quality for safe extended storage and disposal will be developed. Standards will be proposed for the various parameters necessary to establish quality. Techniques to measure activity levels and radionuclide inventories in the different wastes will be refined. These results will be used to develop a reactor waste quality assurance program.

6.1 Waste Form Quality Determination ($451K, 1987-90)

Methods such as ultrasonic, eddy current, and computer tomography measurement techniques for non-destructive examination of waste forms and packages will be studied to develop procedures to detect free liquid, voids, cracks, inhomogeneous waste distribution and other defects in conditioned waste without having to open the waste container or damage the waste form. Suitable procedures for the various wastes will be recommended for incorporation into the overall QA program.

6.2 Radionuclide Measurement ($409K, 1987-90)

Develop and refine methods to satisfactorily identify significant radionuclides in wastes and their individual concentrations to provide inventories of radionuclides and total activity in storage or disposal. Possible approaches include gamma spectroscopy and passive neutron assay, etc. Potential techniques and equipment will be evaluated in respect of their performance and cost. Suitable methods and operating procedures will be proposed to NMMD.

7. ENGINEERED BARRIERS

Depending upon site and waste characteristics, the preferred Ontario Hydro disposal facility options included: (a) engineered trenches, boreholes, and tunnels in soil media at depths of 20-30 m below grade and (b) mined caverns in rock media at intermediate depths of about 100 m. All of these design options included engineered barriers such as concrete walls, floors, etc in trenches and concrete linings in tunnels and boreholes plus grout/concrete backfills to fill all voids. These engineered barriers would provide structural stability, control water ingress, and retard radionuclide migration. This latter feature is particularly important for wastes containing C-14 which cannot be satisfactorily isolated by conditioning and packaging alone. High integrity containers are also being considered for storage and disposal of reactor waste. As Co-60 and Cs-137 are the hazardous radionuclides in most of this waste the use of high integrity containers could allow their placement in storage/disposal without further conditioning.

7.1 Grout/Concrete Backfill for LLW/ILW Disposal Facility ($540K, 1986-90)

The development of a fluidized grout/concrete backfill which can be pumped to fill inaccessible voids between waste packages in a reactor waste disposal facility is continuing. Particular emphasis will be placed on evaluation of optimized backfills' effectiveness in preventing water ingress and retarding C-14 movement. A major part of this effort will involve research into the pore characteristics, permeability, and specific surface area of candidate backfill materials.

7.2 Borehole Backfill Evaluation ($305K, 1986-90)

Work is in progress to evaluate backfill materials in situ in augered boreholes at the BNPD site with particular reference to investigation of radionuclide transport at the backfill/host rock interface. The backfill materials being studied under field conditions include: (a) flyash-concrete grout; (b) sand-bentonite mixture; and (c) compacted glacial till. Data from this work should be useful in the design of the future lysimeter studies planned for BNPD.

7.3 High Integrity Container Materials Evaluation ($450K, 1987-90)

Potential container construction materials such as polyethylene, FRP, concrete, and other durable materials will be studied to define mechanisms and environments causing mechanical deterioration and/or corrosion. Rate limiting features and synergistic effects will be examined in the context of extended storage and possible disposal environments. Potential internal attack on the container from physical or chemical changes to the waste form will be determined. Individual or composite materials capable of providing the target lifetime of 300 years will be identified for NMMD use in engineered barrier studies.

7.4 Extended Storage Effects - Resins/Containers ($140K, 1987-90)

The effects of extended storage of normal operating and decontamination resins on container materials with regard to attack on internal coatings, corrosion of resin liners, embrittlement of HDPE, and attack on concrete will be studied in the laboratory. The effect of radiolysis and time dependent chemical and mechanical factors on resin stability will be investigated. Attention will be paid to defining mechanisms of attack and rates to develop predictions of container service life and identify potential future handling problems.

7.5 C-14 Mobility in Unsaturated Geologic Materials ($230K, 1986-87)

The objective of this study is to evaluate the effect of isotopic exchange between liquid and gaseous CO_2 on mobility of gaseous $^{14}CO_2$ in partially saturated soils. Laboratory tests are continuing to determine the mobility of C-14 in unsaturated geologic materials with particular reference to the rate and magnitude of isotopic exchange between $^{14}CO_{2(g)}$ and $^{12}CO_{2(aq)}$.

7.6 Nuclide Diffusion in Partially Saturated Media ($80K, 1986-87)

Work has been initiated to evaluate the effect of moisture content on the migration rates of reactive solutes in unconsolidated geologic materials. Sandy buffer materials are being considered in this study. Particular emphasis will be placed on determination of bulk pore water chemistries and radionuclide concentrations in the buffer materials.

8. WASTE MANAGEMENT SUMMARY REPORTS

Waste management summary reports will be prepared every five years or at the end of each of the main research program areas whichever is sooner. These reports will collate the findings of individual projects in the given area, document the state of knowledge, draw final or partial conclusions and /or suggest future research objectives.

8.1 Waste Characterization Summary Report

8.2 Waste Conditioning Summary Report

8.3 Advanced Waste Treatment Summary Report

8.4 Process/Equipment Development Summary Report

8.5 Waste Form Performance Summary Report

8.6 Waste Form Quality Assurance Summary Report

8.7 Engineered Barriers Summary Report

Other Activities

In addition to the foregoing direct research we shall keep abreast of other research and technical developments by continuing participation in IAEA coordinated research programs and technical consultant activities, maintaining membership in OECD/NEA and CEC research advisory committees, and possible cooperative projects or scientist exchange with other research institutions.

Program Review

This program will be reviewed annually by both Research Division and Nuclear Materials Management Department to reassess the appropriateness of individual activities to the overall Corporate reactor waste management strategy and reassign priorities, resources, and funding as necessary.

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APPENDIX 1
REACTOR WASTE MANAGEMENT RESEARCH PROGRAM
1986-1990

		1986 $K	1987 $K	1988 $K	1989 $K	1990 $K	Totals $K
1.	WASTE CHARACTERIZATION						
1.1	Incinerable Waste	75					75
1.2	Non-Processable Waste	55	55				110
1.3	Retubing Waste	55					55
1.4	Ion Exchange Resins	80	80	100	100	80	440
1.5	Incinerator Ash		50		50		100
1.6	Miscellaneous Liquid Wastes	35	35				70
2.	WASTE CONDITIONING						
2.1	Misc. Liquid Waste Solidification		50	50	50		150
2.2	Immobilisation Matrices for IX Resin	10	45	45	45		145
2.3	Full Scale Immobilisation			70	30		100
2.4	Immobilisation of Incinerator Ash		50	30			80
2.5	Tritiated Waste Conditioning		40	40	40		120
3.	ADVANCED WASTE TREATMENT						
3.1	Aggressive Decontamination		91	86	43		220
3.2	Plasma Arc Pyrolysis/Melting			150	116	43	309
3.3	IX Resin Volume Reduction		70	110	50	200	430
3.4	C-14 Removal, Fixation and Recovery		70	250	120		440
4.	PROCESS EQUIPMENT DEVELOPMENT						
4.1	Mobile Solidification System	50	110	100			260
4.2	Waste Treatment Equipment			88	103	150	341
4.3	Incinerator Off-gas Filter Efficiency	40	25				65
4.4	Future Incinerator Off-gas Treatment		50	50	50		150
5.	WASTE FORM PERFORMANCE EVALUATION						
5.1	Porosity and Surface Area Measurement	70	60	60	60		250
5.2	Waste Form Durability			59	58	35	152
5.3	Integrated Leaching Test	35	59	59	59		212
5.4	Lysimeter Testing		30	120	120	100	370
6.	WASTE FORM QUALITY ASSURANCE						
6.1	Waste Form Quality		53	53	140	205	451
6.2	Radionuclide Measurement		53	53	120	183	409
7.	ENGINEERED BARRIERS						
7.1	Backfill for LLW/ILW Disposal Facility	20	140	130	130	120	540
7.2	Borehole Backfill Tests	45	60	60	70	70	305
7.3	HIC Materials Evaluation		100	100	120	130	450
7.4	Ext.Storage Effects - Resins/containers		20	40	40	40	140
7.5	C-14 Mobility in Geologic Materials	140	90				230
7.6	Nuclide Diffusion in Unsaturated Media	30	50				80
8.	WASTE MANAGEMENT SUMMARY REPORTS						
8.1	Waste Characterization						0
8.2	Waste Conditioning						0
8.3	Advanced Waste Treatment						0
8.4	Process Equipment Development						0
8.5	Waste Form Performance Evaluation						0
8.6	Waste Form Quality Assurance						0
8.7	Engineered Barriers						0
TOTALS ($K)		740	1536	1903	1714	1356	7249

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